

# Thermal properties research insert

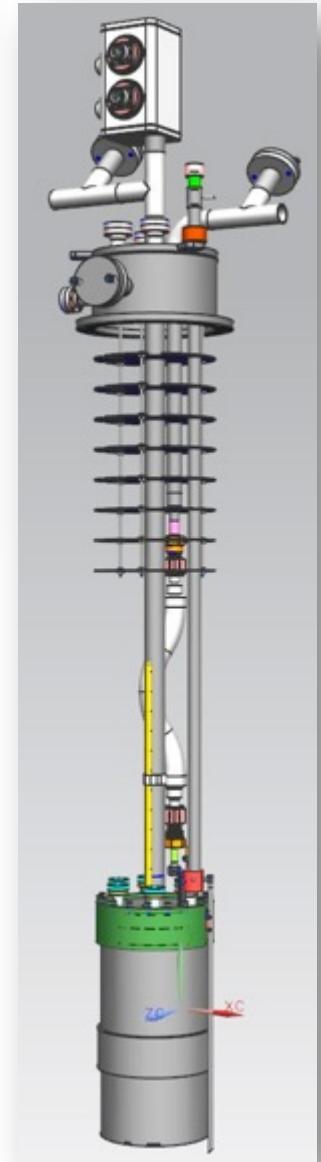
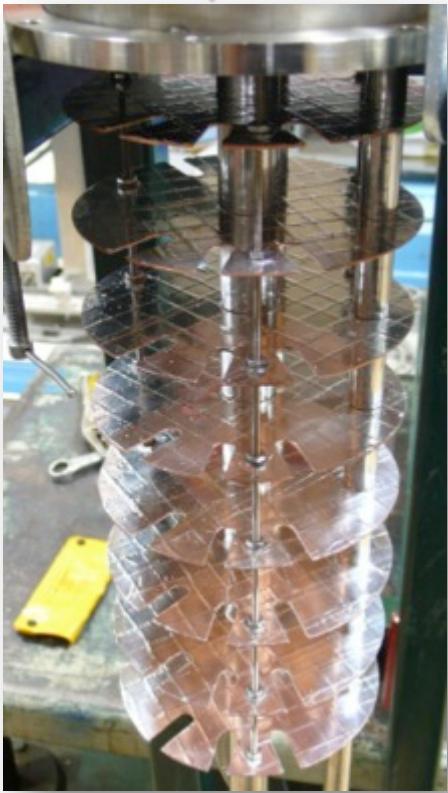
Mikhail Kalyuzhnny  
Bauman Moscow State Technical University

Supervisor: Roger Rabehl  
Mentor: Sergey Koshelev

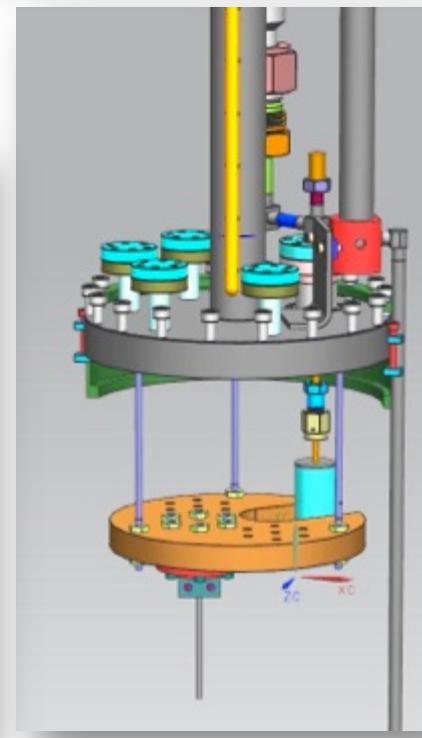
Technical Division, Test & Instrumentation Department, Cryogenic Engineering and Operations

22 August 2012

Pictures by S. Koshelev



**Purpose:**  
**Measurement of the**  
**thermal conductivity and**  
**specific heat of niobium**



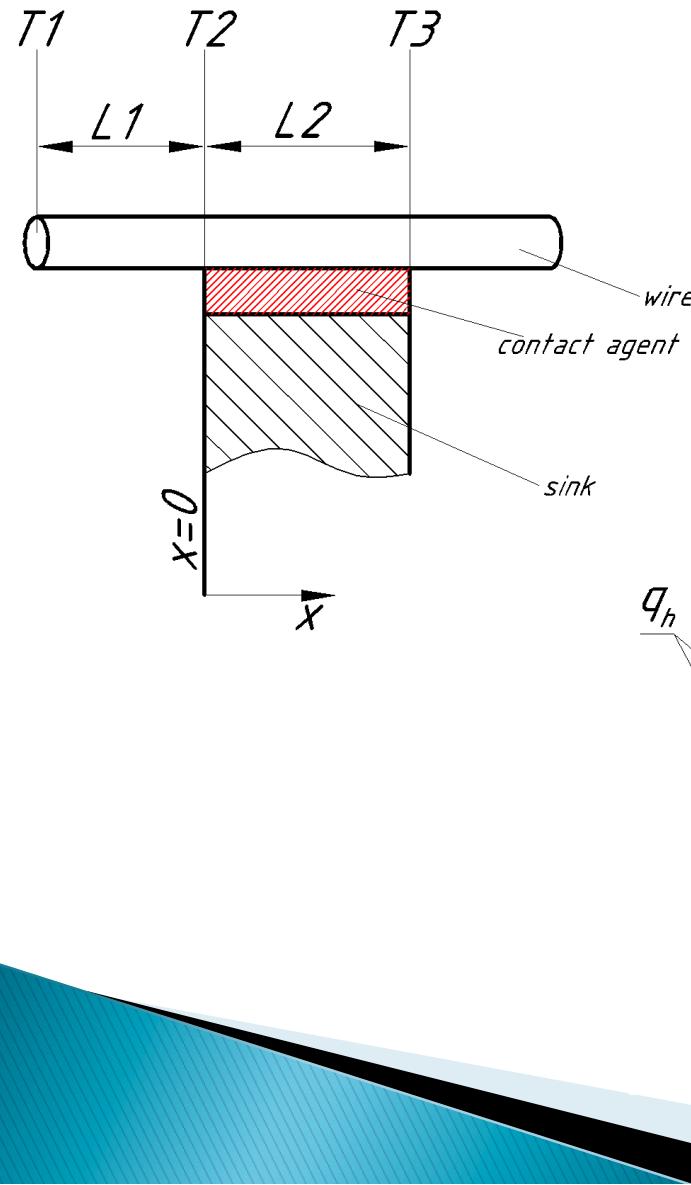
Models by S. Koshelev

# Main Goals

1. Thermal anchoring of wires in cryogenic apparatus
2. Frequency optimization for AC-Temperature Calorimetry

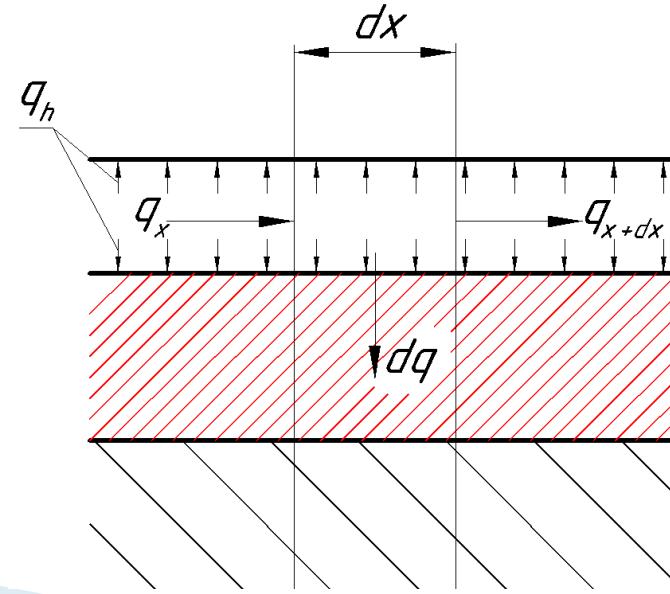


# Thermal Anchoring



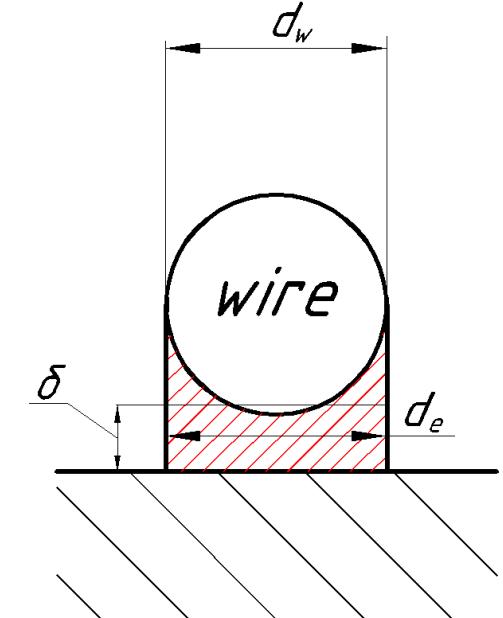
**Thermal balance  
equation**

$$q_{.h} + q_{.x} = q_{.x+dx} + dq$$

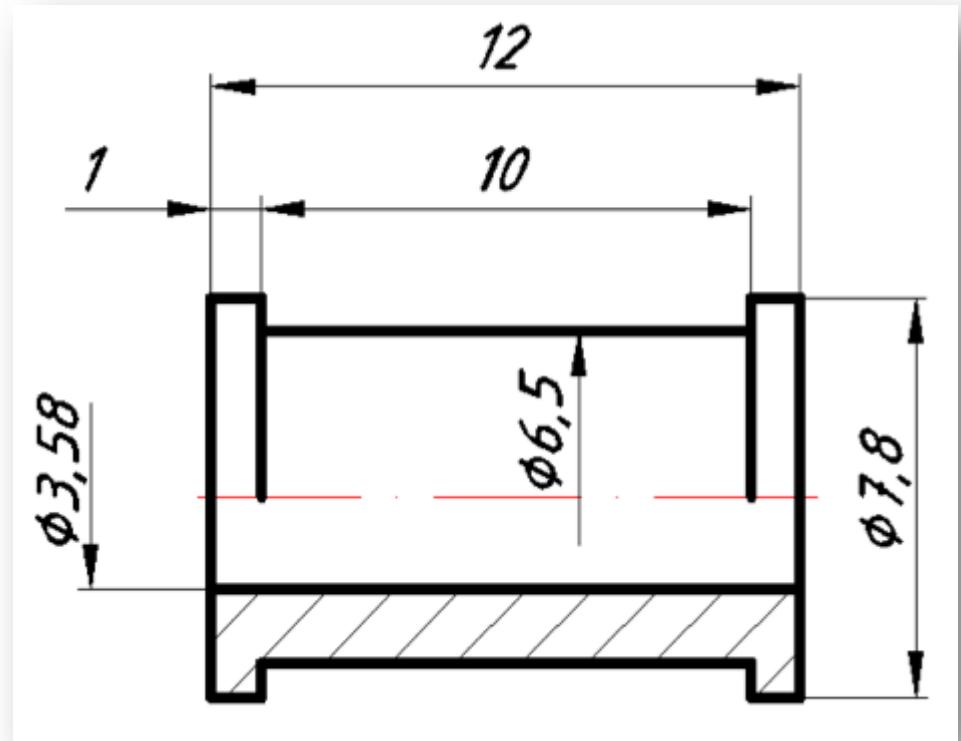
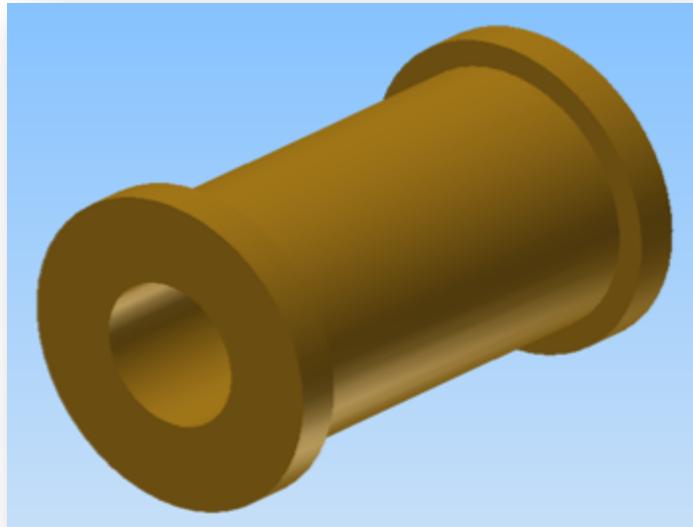


**Assumptions**

- wires are not twisted;
- varnish layer is neglected;
- maximum current is used
- for calculations;



# Copper Bobbin Sink

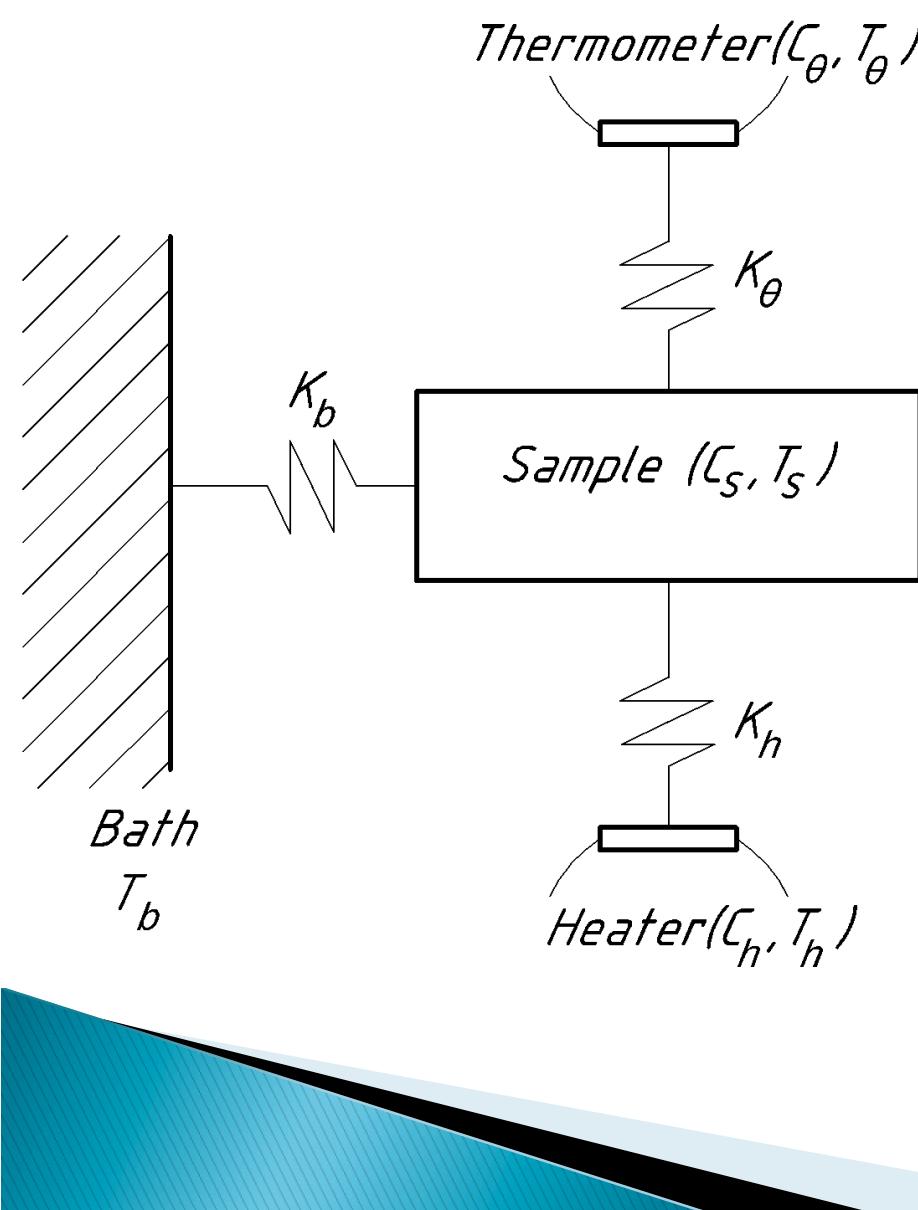


$L=2.19\text{mm}$

$L_{sh}=2.78\text{mm}$

**Difference 21% !!!**

# AC-calorimetry



$$C_h \dot{T}_h = \dot{Q}_h = Q_o \left( \cos \frac{\omega}{2} t \right)^2 -$$

$$- K_h (T_h - T_s)$$

$$C_s \dot{T}_s = \dot{Q}_s = K_h (T_h - T_s) -$$

$$- K_b (T_s - T_b) - K_\theta (T_s - T_\theta)$$

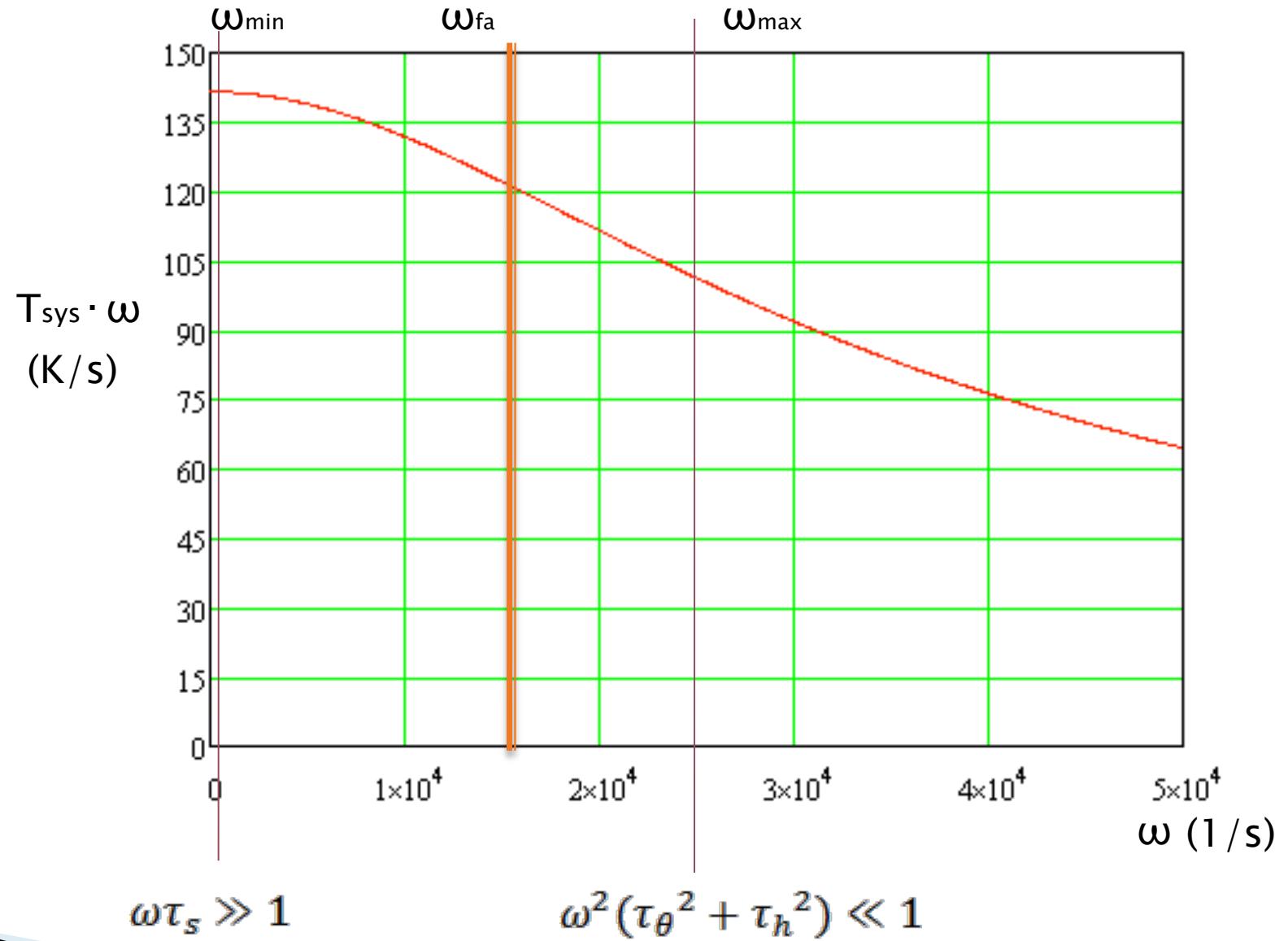
$$C_\theta \dot{T}_\theta = \dot{Q}_\theta = K_\theta (T_s - T_\theta)$$

$$\underline{T_\theta = f(\omega, C)}$$

## Materials for 1.5K measurement

- Sample - Niobium
  - Thermometer – sapphire substrate  
(+ceramic oxynitride)
  - Heater- alumina ceramic +NiCr
- $C_s \gg C_\theta + C_h$
- 
- Thermometer-sample contact - Apiezon N Grease
  - Heater-sample contact - Apiezon N Grease
  - Sample-bath contact - manganin wire (#36)





# Comparison

## Calculation

## Experiment

### Thermal Anchoring

Result temperatures

$$T_2 = 5,3 \text{ K}$$

$$T_2 =$$

$$T_3 = 4,499 \text{ K}$$

$$T_3 =$$

### AC-calorimetry

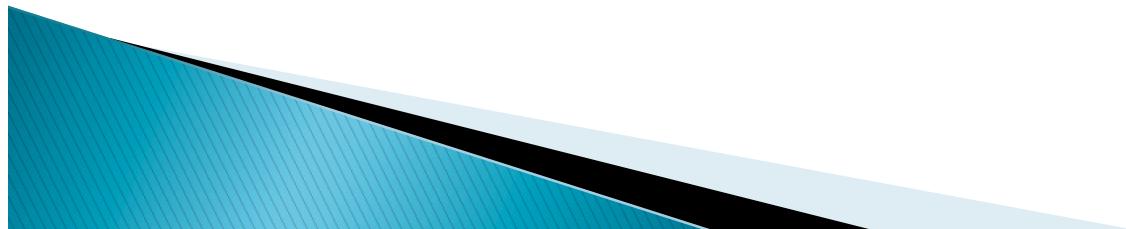
System heat capacity

$$C_{\Sigma} = 1,06 \cdot 10^{-5} \frac{\text{J}}{\text{K}}$$

$$C_{\Sigma} =$$



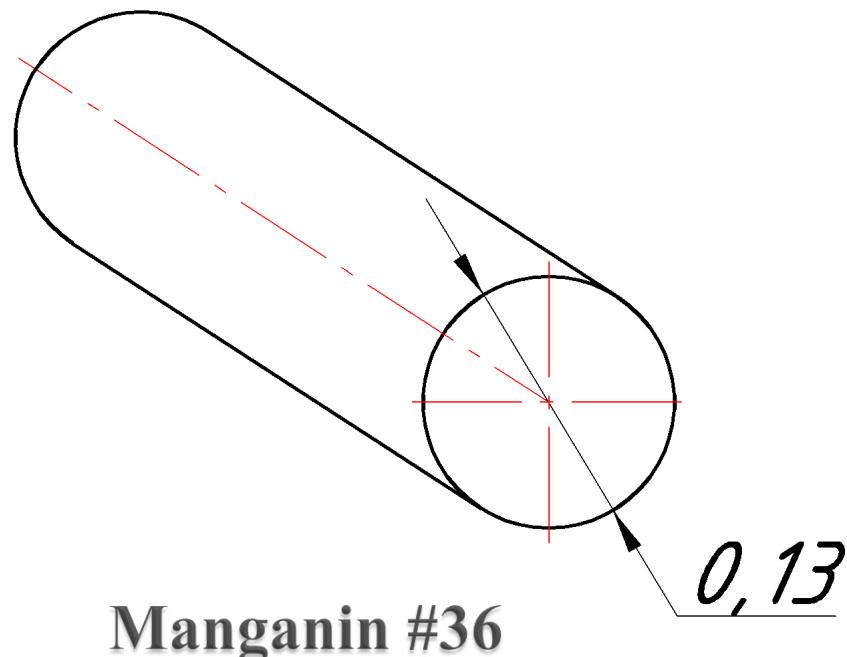
**Thanks for your attention!**



# Backup slide

## Thermal Anchoring

Wire



Thermal balance equation

$$q_{.h} + q_{.x} = q_{.x+dx} + dq$$

$$q_{.h} = I^2 \cdot R = I^2 \cdot \rho \cdot \frac{dx}{A_{.w}}$$

$$q_{.x} = \lambda_{.w} \cdot A_{.w} \cdot \frac{dT}{dx}$$

$$q_{.x+dx} = \lambda_{.w} \cdot A_{.w} \cdot \frac{d(T + dT)}{dx}$$

$$dq = \frac{-d \cdot e \cdot \lambda_{.a}}{\delta} \cdot (T_{.s} - T) \cdot dx$$